Homework #10, PHY 674, 1 December 1995

(E7). For the zinc blende structure, how does the electric dipole representation Γ_{15} break up at X and L and along Δ and Λ ? Use this information to find the selection rules for electric dipole transitions (with and without spin-orbit coupling).

(E8). Do the same for the diamond structure. Warning: At the X-point, there is a difficulty. The dipole operator belongs to a single-valued representation at X, since it is not a Bloch wave. See Table 2-7 in Bassani's book for details.

(E9). An optical phonon at $\vec{k}$=0 in GaAs splits into a TO and an LO phonon, whereas the same optical phonon in Si does not split. Is this in agreement with our results in class about the symmetry properties and classification of lattice vibrations ? Explain this splitting in terms of group theory and crystal field splittings. Hint: Take into account the electric field generated along the axis of the Ga–As bonds.

(E10). Find the compatibility table for the groups D_{4h} and D_{2h}. How does an E_g phonon (in a crystal with D_{4h} symmetry) split when the symmetry is reduced to D_{2h} ?

(E11). Find the $3N$-dimensional character describing the symmetry of the lattice displacements in $YBa_2Cu_3O_6$ (where N is the number of atoms).

(E12). Break up this character into irreducible characters. To which irreducible representations do the phonon modes (how many are there) belong to ? What are the representation of the acoustic phonons ? Which optic phonons are infrared-active ?

Due Date:
Friday, 8 December 1995, 2:10 pm
in the green box in the physics department.

Please use the notation of Bouckhaert, Smoluchowski, and Wigner for labelling the representations of O_h and T_d at the Γ-point. Use the notation of Bassani for the little groups.
There is no grace period this time, since this is the final homework set. I have to grade the homework and report the grades to the DEO for submission to the registar's office.

Dr. Stefan Zollner, A205 Physics, 294-7327, 15 November 1995.
Send questions to: `zollner@iastate.edu`.